Title of the Paper: Climate Change in India: NAPCC and the Road to Sustainable Agriculture

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Brief Bio-line: Dr. Vinita Pandey, with over two decades of teaching experience, is a distinguished academic in Sociology, specializing in Urban Sociology, Development Studies, and Qualitative Research. She earned her doctorate for work on the identity crisis among urban middle-class families and has held key administrative roles, including Head of Department and IQAC Assistant Coordinator. Dr. Pandey has published 8 books, 31 research articles, and completed multiple ICSSR projects. She has designed UGC-approved courses, launched a popular MOOC on Urban Sociology on SWAYAM, and serves as a resource person for HRDCs nationwide. A Vidya Shiromani awardee, she remains dedicated to urban research and youth capacity building.

Introduction

Climate change is one of the largest and most complex problems being faced by mankind. The effects of higher temperatures, variable precipitation, and extreme weather events are influencing not only the economy of developing countries but also the livelihoods of millions of people. UNDP states that climate change is no more an environmental concern and has emerged as the biggest developmental challenge for the planet. Its economic impacts, particularly on the poor, make it a major governance issue as well. The debates and discussions are reflected in conference of parties (CoP) in Copenhagen in 2009 and its subsequent meetings.

COP28 Agriculture, Food, and Climate Action Toolkit, a comprehensive resource designed to help national policymakers and decision-makers accelerate and align climate action with food system transformation. The toolkit summarizes priority actions for integrating agriculture into climate strategies. It showcases best practices from Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs) that effectively incorporate food and agriculture measures. It provides an overview of initiatives, platforms, and tools to assist governments in developing and implementing agriculture and food system policies within their NDCs and NAPs. This initiative aims to enhance global collaboration and support countries in creating more sustainable and climate-resilient food systems. The COP29 Presidency-2024, in collaboration with the Food and Agriculture Organization (FAO), has launched the Baku Harmoniya Climate Initiative for Farmers. This platform aims to unify the fragmented landscape of existing climate initiatives in food and agriculture, making it easier for farmers to access support and financing.

The second Sustainable Development Goal (UNSDG-2), as outlined by the United Nations, aspires to eradicate hunger, ensure food security, improve nutrition, and promote sustainable agriculture by the year 2030 (Kumar and Pant, 2023). This goal is particularly crucial given the persistent prevalence of undernourishment and food insecurity affecting millions of people worldwide. However, achieving this ambitious target is increasingly being threatened by the rapidly changing global climate. In recent years, the planet has witnessed a surge in extreme and unpredictable weather events such as prolonged droughts, intense floods, heatwaves, and erratic rainfall patterns (Singh et al., 2023). These climatic disturbances have a direct and adverse impact on agricultural productivity, undermining both the quantity and quality of crop yields. Agriculture, which forms the foundation of global food production and livelihoods for a significant portion of the world's population, especially in developing countries, is now confronted with multifaceted challenges in the 21st century. Beyond climate change, factors such as soil degradation, water scarcity, loss of biodiversity, and the socio-economic vulnerabilities of smallholder farmers further compound the difficulties in ensuring sustainable food production systems. In this context, addressing the interlinked issues of hunger, climate resilience, and sustainable agriculture has become a critical priority for policymakers, researchers, and communities alike, demanding coordinated global and local efforts.

Objectives

The present paper endeavors to understand the impact of climate change on Indian agriculture (not only in terms of crop productivity and food security but also impact on marginal and small farmers). It aspires to comprehend the various means of ensuring sustainable agriculture especially in the context of National Action Plan on Climate Change (NAPCC) and to present a critique of National Mission on Sustainable Agriculture (NMSA) which is one of the eight missions of NAPCC (missions range from solar energy to sustainable agriculture and strategic knowledge platform for climate change).

Methods

The paper through the secondary data and qualitative review of existing literature, the paper is based on descriptive analysis.

Discussion

Climate Changes in India

The Global Climate Risk Index 2021 calls India the seventh most affected nation due to climate change. (Eckstein etal, 2021). A report published in the Indian National Daily The Hindu, says that due to climate change, the world experienced an average of 41 more days of extreme heat in 2024 (December 27, 2024). According to the European climate agency Copernicus, 2024 was the warmest year on record and the first year with a global average temperature 1.5°C above pre-industrial levels. The scientists identified 219 extreme weather events in 2024 and studied 29 of them. They found that climate change has caused at least 3,700 deaths and displaced millions in 26 extreme weather events. (Copernicus n.d.). The economic impact of climate change is very severe. The macroeconomic damages from climate change are six times larger than previously thought. Exploiting natural global temperature variability, we find that 1°C warming reduces world GDP by 12%. (Bilal and Kanzig, 2024). Displacement and reduction in GDP are the major factors for social exclusion

India is one of the countries which is most vulnerable to climate change. The livelihoods of large number of poor people are based on natural resource and that too with a high dependence on rainfall. While water sustains life, it all too often wreaks havoc through devastating floods and droughts. According to the World Bank in 2020, pressure on India's water, air, soil, and forests was the highest in the world. (http://web.worldbank.org/archive/website01291/WEB/0__CO-78.HTM). In India, according to IMD data released by the statistics ministry, average temperatures have increased by 0.6 degrees Celsius (° C) between 1901-10 and 2009-18. Further the World Bank estimates that, if climate change continues unhindered, then average temperatures in India could reach as high as 29.1° C by the end of the century (up from 25.1° C currently). (Padmanabhan, 2019)

India faced extreme weather events on 93 per cent of days in the first nine months of the year 2024 marked by heat and cold waves, cyclones, lightning, heavy rain, floods, and landslides. These events claimed 3,238 lives, affected 3.2 million hectares of crops, destroyed 235,862 houses, and killed approximately 9,457 livestock. This reported damage is likely an underestimate due to incomplete data collection on event specific losses, particularly public property and crop damage. (Pandey and Sengupta, 2024)

Climate change affects the soil moisture, groundwater recharge, and frequency of flood or drought, water cycle, production patterns of different crops and thus the agricultural productivity. All these changes will escalate the vulnerability of the small and marginalized farmers, agricultural labourers, landless and the poor. Several climatic changes have been observed in India. For instance, at national level, increase of 0.4° C has been observed in surface air temperatures over the past century. (Hingane etal 1985). It is argued that India is particularly vulnerable to predicted climate changes because of its high population density, low adaptive capacity, several unique and valuable ecosystems (coral reef, large deltaic region with rich biodiversity) and vast low-altitude agricultural activities (Roy, 2007).

Climate change is also manifesting itself in the rise in extreme hot days (temperatures exceeding 35° C) across Indian cities. For instance, in Delhi, the number of days where temperatures have crossed 35° C has increased to 1,613 in this decade (2009-18) from 1,009 in 1959-68. Other major cities, such as Mumbai, Bengaluru, and Hyderabad, have also seen similar increases. In cities, which are epicenters of economic activity, rising temperatures can increase the spread of diseases and hurt productivity. And, in coastal cities, climate change-induced rising sea levels also pose an additional threat through more frequent flooding.

According to the Global Climate Risk Index released by Germany-based think tank, German watch, India is the 14th most climate change-affected country in the world. In terms of global greenhouse gas emissions, India's share remains significantly lower than those of both the US and China. In many ways, India is paying for the excesses of the developed world. (Padmanabhan, 2019)

There are also trends of extreme weather events in terms of more frequent droughts followed by less severe droughts. Scientists, while analyzing a daily rainfall data set, have shown (i) a rising trend in the frequency of heavy rain events, and (ii) a significant decrease in the frequency of moderate events over central India from 1951 to 2000. It has been estimated that sea level rise was between 1.06-1.75 mm per year in the north Indian Ocean in last 40 years. This rise is consistent with 1-2 mm per year global sea level rise estimates of the IPCC. The intensity of Indian Summer Monsoon is projected to increase in the beginning of 2040 and by 10% by 2100. (Rupa, etal, 2003)

According to the World Bank, central districts in India are the most vulnerable to climate change because they lack the infrastructure and are largely agrarian. In these districts, the World Bank suggests that GDP per capita could shrink by nearly 10% by 2050 because of climate change. (Padmanabhan, 2019)

Impact of Climatic Changes on Agriculture

Agriculture is sensitive to climate change. Climate change leads to melting of glaciers leading to rise in sea levels. The rise in sea levels, even by a meter may displace millions of people and it would also lead to ingress of saline water and salination of ground water and surface water in coastal areas. Salt water intrusion in low-lying agricultural plains could lead to food insecurity, further spread of water-related diseases and reduced freshwater supplies. (https://www.undp.org/content/dam/india/docs/undp_climate_change.pdf). The melting glaciers increase the flood risks. Floods and drought are thus projected to multiply as a consequence of climate change leading to huge crop loss and leave large patches of arable land unfit for cultivation thus threatening food security.

Rice, wheat, maize, sorghum, soya bean and barley are the six major crops in the world grown in 40% cropped area, and contribute to 55% of non-meat calories and over 70% of animal feed (FAO, 2006). The crop model indicates that in South Asia, average yields in 2050 for crops will decline from 2000 levels by about 50 percent for wheat, 17 percent for rice, and about 6 percent for maize because of climate change. (IFRI, 2009)

The variations in monsoon rainfall and temperature changes within a season impacts food production. The food production was to the tune of 300 metric tonnes in 2020. Demand projections for food grains is 345 million tonnes by 2030 and high-value commodities of horticulture, dairy, livestock and fish is increasing faster than food grains by more than 100 per cent. (Kumar etal, 2020). Economic Survey 2023-24 says that the Indian agriculture sector provides livelihood support to about 42.3 per cent of the population and has a share of 18.2 per cent in the country's GDP at current prices. Studies by Indian Agricultural Research Institute (IARI) and others indicate greater expected loss in the Rabi crop. Every 1°C rise in temperature reduces wheat production by 4-5 metric tonnes. Small changes in temperature and rainfall have significant effects on the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. Pathogens and insect populations are strongly dependent upon temperature and humidity, and changes in these parameters may change their population dynamics. Other impacts on agricultural and related sectors include lower yields from dairy cattle and decline in fish breeding, migration, and harvests. Global reports indicate a loss of 10-40% in crop production by 2100. (https://www.iari.res.in/files/ClimaticRisks.pdf)

Indian climate and rains are dominated by the southwest monsoon. It is critical for the availability of drinking water and irrigation for agriculture. Agricultural productivity is affected by climate in two ways. Firstly, owing to direct effects from changes in temperature, precipitation, or carbon dioxide concentrations. Secondly through changes in soil moisture and the distribution and frequency of infestation by pests and diseases.

India's marginalized farming communities are highly vulnerable to climate change impacts like droughts and erratic rainfall. Policies can support climate-resilient farming techniques and provide financial safety nets. Agricultural productivity is affected by climate in two ways. Firstly, owing to direct effects from changes in temperature, precipitation, or carbon dioxide concentrations. Secondly through changes in soil moisture and the distribution and frequency of infestation by pests and diseases.

Kumar and Parikh (2001) found that farm level net revenue would decline by 9 to 25 per cent. They showed that the economic impact would be significant even after accounting for farm-level adaptation. The loss in net revenue at the farm level is estimated to be between 9 and 25 per cent for a 2.0 Celsius to 3.5 Celsius rise in temperature. Sanghi and Mendelsohn (2008) also attempted to incorporate adaptation options while estimating the agricultural impact. They calculated that a 2° C rise in mean temperature and a 7 per cent increase in mean precipitation would reduce net revenues by 12.3 per cent for the entire country. This can have very serious consequences.

According to data from Centre for Science and Environment and Down to Earth atlas, the impact on agriculture has been severe, with extreme weather affecting at least 3.2 million hectares of cropped land in 2024, a 74 per cent increase from the 1.84 million hectares damaged in 2022. However, this number likely underestimates the true damage, as data from major agricultural states such as Uttar Pradesh and Haryana was unavailable. (Pandey and Sengupta, 2024)

National Action Plan on Climate Change (NAPCC)

NAPCC stands for the National Action Plan on Climate Change, a program launched by the Government of India in 2008 to address climate change mitigation and adaptation, encompassing eight national missions. It is an assessment of the blow of climate change and strategies needed to deal with climate change. The eight missions are: National Solar Mission; National Mission for Enhanced Energy Efficiency; National Mission on Sustainable Habitat; National Water Mission; National Mission for Sustaining the Himalayan Ecosystem; National Mission for a Green India; National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change. Let us discuss in detail about NMSA.

National Mission for Sustainable Agriculture (NMSA)

Indian agriculture remains predominantly rainfed covering about 60% of the country's net sown area and accounts for 40% of the total food production. Thus, to ensure food security for growing population, conservation of natural resources in conjunction with development of rainfed agriculture is significant. NMSA has thus been formulated for enhancing agricultural productivity especially in rainfed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation. (https://nmsa.dac.gov.in/). The National Mission for Sustainable Agriculture (NMSA) was launched in 2014-15. The ten key dimensions of NMSA include: 'Improved crop seeds, livestock, and fish cultures,' 'Water Use Efficiency,' 'Pest Management,' 'Improved Farm Practices,' 'Nutrient Management,' 'Agricultural insurance,' 'Credit support,' 'Markets,' 'Access to Information' and 'Livelihood diversification.'

Schemes under NMSA include the following:

- Rainfed Area Development
- Soil Health Management
- Sub Mission on Agro Forestry
- Paramparagat Krishi Vikas Yojana
- Soil and Land Use Survey of India
- National Rainfed Area Authority
- Mission Organic Value Chain Development in North Eastern Region
- National Centre of Organic Farming
- Central Fertilizer Quality Control and Training Institute

NMSA focuses on several priority areas. These include improving water use efficiency through technology-driven solutions like drip and sprinkler irrigation systems under the 'Per Drop More Crop (PDMC)' component of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). It also promotes the responsible use of chemical fertilizers, supported by the "Soil Health Card" scheme, which provides farmers with essential information about soil nutrient status. Additionally, the mission aims to empower farmers with climate-smart agricultural practices through initiatives such as the National Mission on Agriculture Extension & Technology and the National Initiative for Climate Resilient Agriculture (NICRA).

As the world's most populous country undergoing rapid growth in per-capita income, ensuring India's future food and nutrition security will require a comprehensive and integrated framework, even if pursued incrementally. This framework must drive coordinated progress across a wide range of targeted interventions. Key priorities should include promoting dietary shifts towards low-emission foods; encouraging the balanced and efficient use of water and chemical fertilizers; enhancing soil conservation measures; strengthening pest and disease management; and expanding organic farming practices. It should also focus on crop diversification based on emission profiles, greater adoption of climate-resilient and high-yielding seed varieties — particularly among small and marginal farmers — and the promotion of sustainable livestock breeding practices. Additionally, preserving ecological resources by halting deforestation and preventing the encroachment of mangroves, curbing crop residue burning, advancing carbon sequestration initiatives, and minimizing food waste throughout the supply chain are essential components. A truly integrated approach must involve regular, organized monitoring of progress in a holistic manner, timely adjustments based on periodic performance reviews, and the continuous introduction of new, technology-driven solutions. Strengthening agricultural extension services and expanding climate literacy initiatives will also be crucial in building long-term resilience and ensuring sustained impact. (Pattanaik, 2025)

IASC (2009) suggested key messages on food security in a changing climate scenario. Climate change will act as a multiplier of existing threats to food security. By 2050, the risk of hunger is projected to increase by 10–20 per cent and child malnutrition is anticipated to be 20 per cent higher compared to a no-climate change scenario. The other issue of concern is achieving food security under a changing climate scenario. It requires substantial increase in food production and improved access to adequate and nutritious food on the one hand and the capacity to cope with the risks posed by climate change on the other hand.

NMSA encourages the use of organic manures, biofertilizers, and biopesticides. A study analyzing data from the National Sample Survey (2018-2019) found that adopting these inputs led to an average increase of ₹3,415 per hectare in paddy harvest value. (Jha etal, 2024). NMSA's objectives align with national food policies, integrating environmental sustainability into agricultural strategies. This alignment ensures that sustainable practices are part of broader efforts to enhance food production. (Brown etal., 2021)

Strengthening NMSA

NMSA seeks to transform Indian agriculture into an ecologically sustainable climate resilient production system. Simultaneously it aims at realizing its fullest potential and ensuring food security, equitable access to food resources enhancing livelihood opportunities and contributing to economic stability at the national level. Nevertheless, there are certain areas of improvement which can facilitate strengthening NMSA. Some of them are listed below

Technology and Mechanization: The goals are skewed towards big farmers and are technology-focused. The farmers were not involved in the design process; important issues such as crop diversity, non-farm incomes, ways to address fuel and fertilizer shortage, women and their rights have received inadequate attention. Involving more stakeholders can help in strengthening NMSA at grassroot level. NMSA gives significant importance to mechanization of farming. This may be a great challenge for the farmers of small and marginal land holdings. The technological solutions should be cost effective, easily accessible, and relevant for the small and marginal farmers who comprise more than 80% of farming community in India. One time subsidy to purchase big machines might enable small farmers to buy big machines such as tractors, but will lead them to debt trap for arranging the money for maintenance cost. However, use of machinery boosts production only when the soil health is good and there is availability of water.

Financial Allocations and Investment: The NMSA laid down INR 1, 08,000 crore up to the end of the 12th FYP and a major portion (60%) was utilized to adopt technology, products, and practices. Infrastructure development and R&D together was allocated 35% of the total resources, whereas about 5% of allocation was deployed for capacity building. Thus, the amount spent on capacity building is very less and adaptation support for the farmers is lacking. There is an urgent need for increasing investment in dryland agriculture; however, NMSA does not provide much progress into that. There is also inadequate emphasis on livestock management beyond improving dietary practices to reduce emission from enteric fermentation. Common property resources and development of pastures, which can be a good livestock management strategy is completely unattended.

Biotechnology and Genetic Engineering: NMSA proposes biotechnology as panacea for all problems of agriculture. Genetic Engineering is likely to take care of all crop requirements viz. resilience for drought and submergence, salinity tolerance, improved nitrogen fixation, and water efficiency. However, there are serious concerns with regard to loss of potentially useful genetic biodiversity. Such diversity is critically needed for coping strategies. It shall also lead to monopoly by biotechnology companies.

Ecosystem: Bio-fertilizers, improved farm practices, lack of support to organic farming and commitment to agro-ecological approach also do not fare better in NMSA. Access to information is mainly leveraged to support markets, rather than farmers through minimizing information irregularity and inviting public private partnership in technology-based solution. The three tier institutional structure (national, state and district level) proposed for management and implementation does not have place for farmers. Sustainable Agriculture is based on understanding of ecosystem services, the study of relationships between organisms and their environment. But the proposed strategy of the mission gives importance to water and largely ignores the usage of chemical fertilizers.

Innovation and Capacity Building: NMSA has been partly successful in identifying the challenges faced by agriculture and how they will be worsened in a changing climate. Yet it has failed to find innovative solutions. While aiming to promote resource-efficient technologies, it has not addressed unhealthy agricultural practices. Moreover, it seems to be targeting the big farmers, who can afford the new technologies, leaving the small and marginal farmers vulnerable. (Swain, 2014). The NMSA neither clarifies how the technologies will be governed nor addresses the weak agricultural extension services. In addition, the lack of adequate credit or an insurance facility would be a barrier for wider adoption of these technologies. Finally, weak institutional and human capacity will be a key challenge for effective implementation. An obscure strategy that merely addresses a few adaptation concerns falls short of a sustainable pathway for agricultural development. (ibid)

Building Resilience and Knowledge Transfer: There is no sufficient consideration for promoting sustainable agriculture practices. Resilience to specific effects of global warming such as floods and droughts are ignored. Innovation is defined purely in terms of market driven lens and pockets of success in local farming, which are valuable in adaptation, have not been highlighted. (Byravan and Rajan, 2012). The mission is technology driven but it is not very clear about who would control the technologies and there are also questions on its affordability. The technologies will increase the usage of chemicals leading to greater emission of greenhouse gas emissions. Trade and economic policies will conflict with agricultural policies and thus could lead to an increase in emissions. (ibid). There is need to strengthen transfer of knowledge and experiential learning from farmers to the laboratory.

Livestock: It is a major contributor to India’s food requirements and accounts for 40 percent of agricultural emissions. Yet it gets no mention in India’s low-carbon strategy. Productivity in the livestock subsector is highly vulnerable to temperature rises. NMSA could further support simple interventions like feed quality improvement and health and reproduction management, achievable through an improved extension service, have the potential to increase productivity, improve resilience, and slash emissions.

Adaptation Strategies: NMSA does not address low-carbon development pathway since dependence on chemical fertilizers has not been reduced. The entire process should have instead identified effects as a result of warming for specific scenarios in each agro-climatic zone and then develop responses in step wise manner. The lab to land approach is likely to benefit large farmers and not small-scale farmers. (Byravan and Rajan, 2012). The mission is not very elaborate on how it will support agricultural adaptation, which is largely autonomous, and help farmers and livestock bearing the burden of the changing climate.

The mission acknowledges the need to reduce emission from the agricultural sector. The current focus is on soil carbon sequestration (mainly with the objective of generating finances through private participation) which will impact the small and marginal farmers in least developed and developing countries. In countries like India, where majority of the farmers (more than 80%) possess a land holding smaller than 2 ha, the rush for sequestration will lead to them losing their lands, sovereignty over their produce, choice and means of production to the greedy private project developers lurking on the horizon (PAIRVI 2012).

Traditional Agricultural Practices: NMSA should encourage efficient traditional agricultural practices. Land leveling, mulching, and crop diversification are all traditional practices that reduce the need for input resources like water and fertilizer. These inexpensive practices reduce the need for inputs, and help prevent erosion, preserve soil nutrients, suppress weeds, and increase fertility. Crop residues that are mostly burnt in the field, contributing to emissions and local air pollution, can be used productively as mulch. Similarly, agroforestry as a farming practice has tremendous benefits for productivity, resource efficiency, adaptation, and carbon sequestration. More modern practices like soil fertigation and systemic rice intensification can further improve resource use efficiency and productivity.

NMSA is a promising endeavor to address the issues of agriculture and climate change. However, the priorities and strategies need to be strengthened; greater focus on mechanisms for synergy and collaboration is required along with developing the human resource capacity at various levels of implementation.

The Road Ahead

The challenges emerging from climate change has necessitated greater ingenuity, innovation, and sustainability to meet the food requirements of the population. The eight missions of NAPCC including NMSA is a great effort to address climate change.

NMSA should promote demand-driven approach, accounting for local political-economy and environmental contexts for better food security. Agriculture must transform to adapt to a changing climate, meet food demand, and reduce emission intensities per output. A climate-responsive development strategy is the need of the hour to achieve the goals of development, adaptation and mitigation.

NMSA should strengthen adaptation strategy to enhance resilience. This can be done by preparing the communities to deal with resource scarcity, exploring sustainable alternatives and using resources efficiently. This will help to address climate change-induced stress, extreme events, and their intensity. Substantial cuts in water demand could be achieved by adopting efficient irrigation technologies such as the drip and sprinkler, and much of the remaining demand could be met by extending and enhancing the surface irrigation network. Rainwater harvesting and groundwater recharge initiatives, combined with better irrigation pump efficiency can facilitate better water availability for agriculture. These initiatives will raise resilience to imminent water scarcity without conceding the productivity. The other benefits include reduced energy consumption and lower methane emissions from flood irrigation.

The agricultural subsidy policies and food procurement policies must be realigned to value scarce resources, and should incentivize resource-use efficiency and conservation in agriculture. For example, better support prices for water-efficient crops and varieties could encourage their adoption, while substituting regressive energy and fertilizer subsidies with subsidies for efficient irrigation technologies could help poorer farmers.

Conclusion

Addressing the diversified agriculture related issues and concerns require inclusive approach using community level knowledge that is as relevant at the local scale. Exposure and vulnerability to climate change, populations will become more vulnerable. This new challenge needs to be viewed within a broader political economy perspective on agriculture. Two elements – introducing crop diversity and supporting rain-fed agriculture can build resilience to climate variability. Further, in a context where demand for food grains is going to increase by 30-50% in the next few decades, new and more organised adaptation strategies need to be worked out. Agriculture and climate change need collaborative research and action and to scale up alternatives emerging from the ground to the policy level. An inclusive, collective, and community-based process that brings together farmers, people’s movements, scientists, academicians, policy makers, political actors, and civil society groups, can respond to the twin challenges of the agrarian and climate crises.

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